

BROADBAND SEISMIC EXPERIMENTS IN SOUTHWEST AND NORTHEAST CHINA

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ABSTRACT

Since August 2001, we have conducted two broadband portable seismic experiments in China to collect seismic data for advanced studies on regional crustal and mantle structures, earthquake prediction, characteristics of wave propagation, and earthquake and explosion sources. The first one is in Yunnan province, southwest China, while the second experiment is in Jilin and Heilongjiang provinces, northeast China. The experiment region in southwest China is situated in a transitional tectonic region between the uplifted Tibetan plateau to the west and the Yangtze continental platform to the east. The region displays varying crustal thickness from 35 km to over 60 km with seismic activity strongly associated with the mapped active faults. The portable seismic network, consisting of nine stations equipped with STS-2 seismometers and RefTek data loggers, and 10 stations with Chinese broadband instruments, is deployed in the region of 98-105°E, 21-29°N. There are also 23 permanent digital broadband seismic stations recording in the region. Yunnan has the strongest intra-plate seismic activities in China. Moreover, Yunnan is a very interesting area considering its position relative to several strong seismic zones in China, such as Tibet, Xinjiang, Sichuan, and North China, as well as those in Burma, India-Pakistan, Tonga-Fiji, Japan, and the west coast of South and North America. The experiment region in northeast China lies near the China-North Korean border, in the region of 124-130°E, 41-48°N. The region is characterized by volcanic activities accompanied with low-level seismicity. Other active seismic zones are the Haicheng area in Liaoning province as well as those in the Korean Peninsula. The northeast portable network consists of 10 broadband instruments.

This is the third year of this project. All the waveforms have been converted into Seismic Analysis Code (SAC) formats, and are ready for delivery. A final report is in preparation. This paper is a brief summary of the three years' deployment work. During the experiments we recorded several moderate ($M=4.5-6$) local earthquakes, including one located only 100 km north from the auxiliary International Monitoring System (IMS) station KMI. These moderate earthquakes are well surveyed by the provincial Yunnan Seismological Bureau and yield high quality ground-truth information. The rare, $M_W = 7.3$ deep earthquake (depth 581.5 km) in northeast China was also recorded. A large number of local events are routinely recorded among which many are believed to be industrial explosions. Moderate to large earthquakes in other parts of China, as well as large events worldwide, are also routinely recorded, including the November 14, 2001, $M_s=8.0$ Qinghai earthquake; December 18, 2001, $M_s=7.3$ Taiwan earthquake; September 11, 2001, $M_s=6.4$ Iran earthquake; October 12, 2001, $M_s=7.3$ Mariana earthquake; January 2, 2002, $M_s=7.6$ Vanuatu Islands earthquake; March 3, 2002, $M_s=7.2$ Hindu-Kush earthquake; June 22, 2002, west Iran earthquake; August 19, 2002, $M_W = 7.7$ Fiji earthquake; September 8, 2002, $M_s=7.8$ Papua coast earthquake; October 10, 2002, $M_s=7.7$ Irian Jaya, Indonesia earthquake; and November 3, 2002, $M_s=8.3$ central Alaska earthquake. More over, the June 28, 2002, $M_W = 7.3$ deep earthquake (depth = 581.5km) was recorded locally, which provided invaluable waveform data for studies on regional structure and the mechanism of deep earthquake. In conclusion, this project provides a very good database for studies on the source, path and site terms of regional seismology.

OBJECTIVE

The major purpose of this project is to collect fundamental ground-truth data for advanced studies on regional crustal and mantle structures, earthquake prediction, and regional characteristics of wave propagation and seismic sources in southwest and northeast China, by deploying a broadband portable seismic network in the two areas. The region in southwest China is situated in an evolving tectonic region transitioning between the uplifted Tibetan plateau to the west and the Yangtze continental platform to the east. The region displays varying crustal thickness from 35 km to over 60 km, and seismic activity strongly associated with the mapped active faults. Figure 1 shows the topography of the Yunnan province and the layout of our broadband network. The red triangles are STS-2 seismometers from the US, while the red circles are Chinese broadband instruments (the long-period corner at 20 s) from our Chinese collaborators. Yunnan has the strongest intra-plate seismic activities in China. There are several strong seismic zones in its surrounding areas, such as Tibet, Sichuan, Burma, and India. There is also an abundance of mining activity in this area. Moreover, the distances from the Yunnan area to many of the strongest seismic zones in the world, such as the Tonga-Fiji, the east coast of North and South America, and the Japan-Kuril region, make the Yunnan area an ideal location for tectonic and structure studies recording various seismic phases. Therefore, the strong seismicity and the intense mining activity in Yunnan and its surrounding areas, as well as its unique position relative to many strongest seismic zones in the world, provide the foundation for the success of this deployment. The deployment region in northeast China is in Jilin and Heilongjiang provinces, across the border between China and N. Korea. The region is characterized by a large plain with the exception of the Changbai Mountain along the China-N. Korea border (Figure 2). Although the seismic activity in northeast China is not as strong as that in the southwest, there are some moderate seismic zones to the south in Liaoning province and in North Korea (Figure 3). Moreover, there is some volcanic activity present in the Changbai Mountain area that generates significant seismological research interest in the area. The important position of northeast China allows our deployment in the region to provide valuable information on the regional seismology of the Northeast China Plain and North Korea.

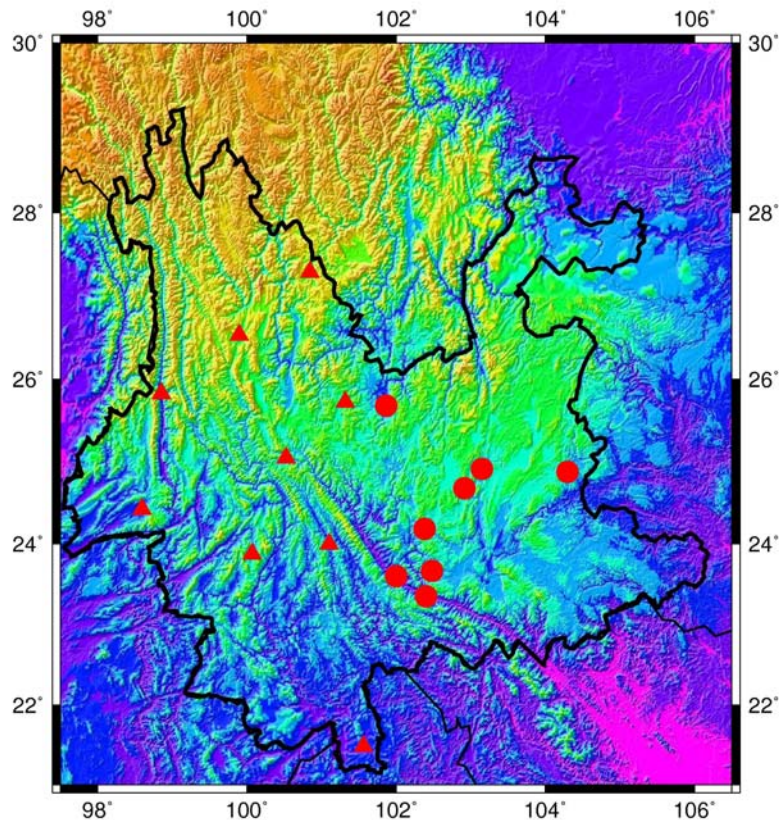


Figure 1. The topography of the Yunnan province and the layout of our broadband network. The red triangles are STS-2 seismometers, while the red circles are Chinese broadband instruments (the long period corner at 20s).

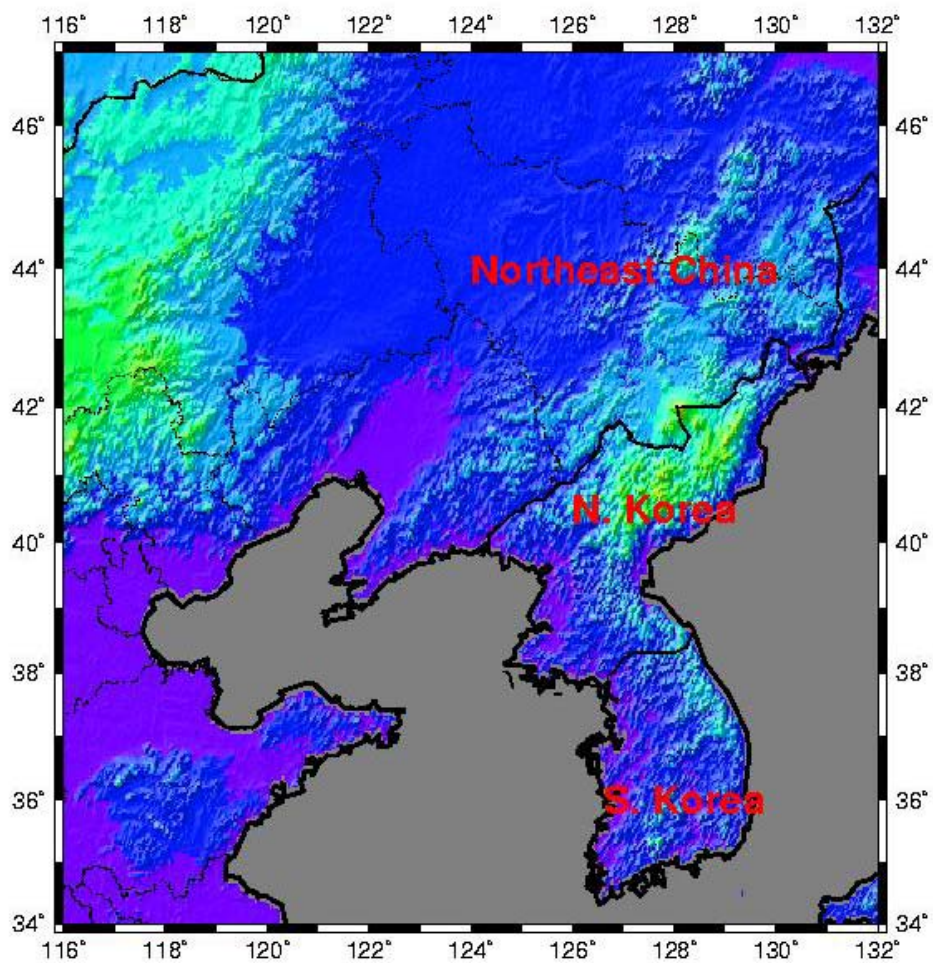


Figure 2. The topography of northeast China and the Korean peninsular. The northeast China region is characterized by a large plain with the exception of the Changbai Mountain along the China-N. Korea border.

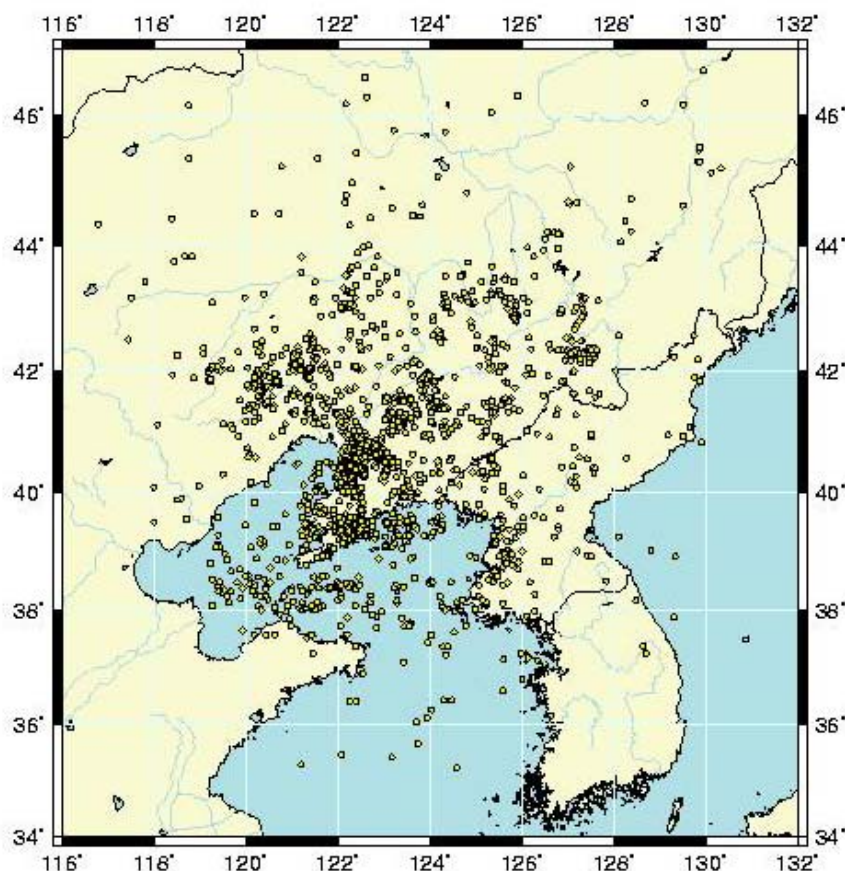


Figure 3. The seismicity of northeast China and North Korea during the past two years.

RESEARCH ACCOMPLISHED

This is the third year of the project. All the waveforms have been converted into Seismic Analysis Code (SAC) formats and are ready for delivery. A final report is in preparation. This paper is a brief summary of the three years' deployment work. Except for one station, all the instruments are deployed alongside the existing short-period analog seismic stations operated by the provincial seismological bureaus in southwest and northeast China. The instruments are installed in vaults that are typically 30-m deep extending horizontally into the hillside. Since these piers were normally professionally built to seismological standard, the data quality of this deployment is on average very high. The local provincial bureaus provide the support in the security and maintenance of the instruments.

The data have been routinely processed. Our analysts have screened a large number of recorded waveforms recorded and constructed a waveform database. Basically, the database includes three kinds of events: the small to moderate local-regional earthquakes, the industrial explosions, and the moderate to large earthquakes at teleseismic distances.

Local Earthquakes

Several moderate local earthquakes occurred during our experiment. After such an event, the provincial seismological bureaus usually dispatch exploration teams to perform on-site geological and geophysical surveys. Therefore, they provide excellent ground-truth information. Figure 4 is the vertical waveform recorded across our network for an M=5 earthquake at Jinggu on September 4, 2001. The epicentral distances to the stations in our network are from 50–400 km.

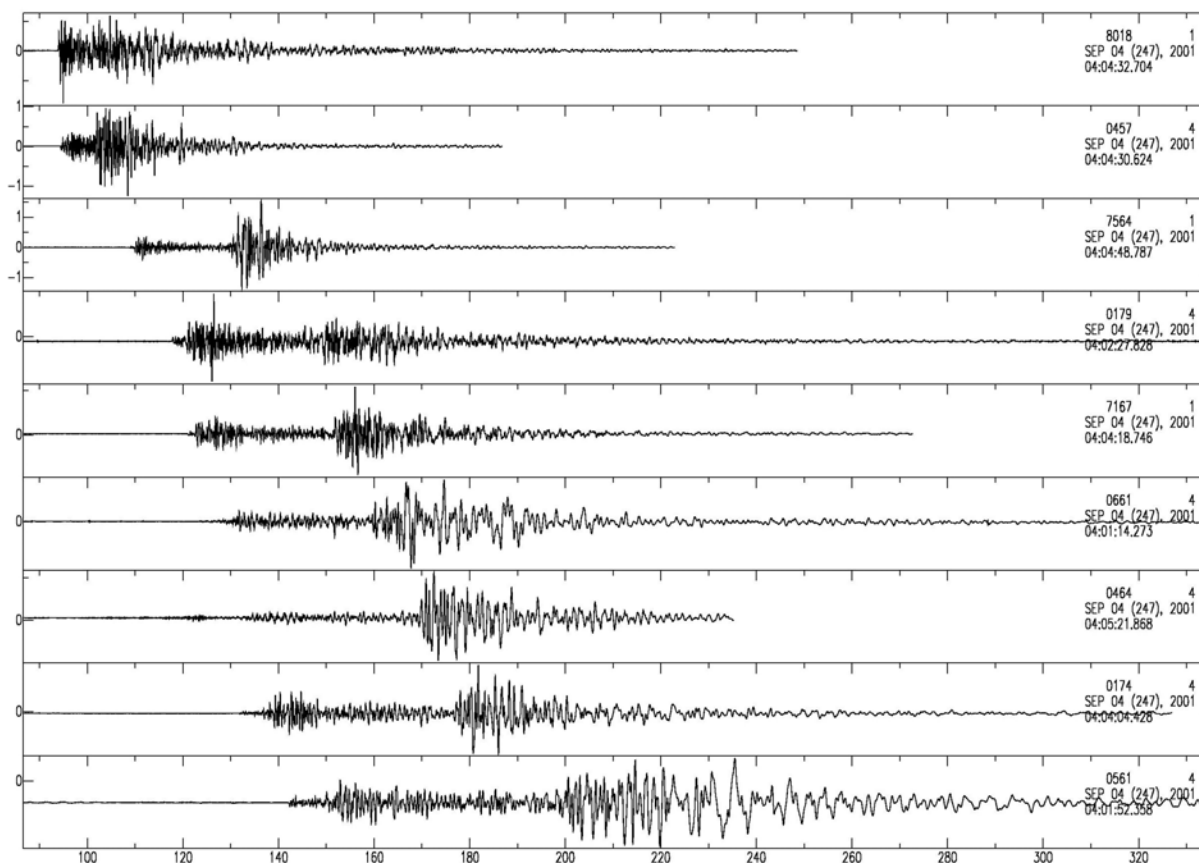


Figure 4. The vertical component of the waveforms of the September 4, 2001 Jinggu earthquake recorded across the Yunnan network. The epicentral distances to the stations in our network are from 50 km (Lincang, the top trace, to 400 km, Ninglang, the bottom trace).

Screening of Industrial Explosions

The provincial earthquake catalogs, compiled from recordings generated by the high-density, short-period analog seismic network in the deployment regions and some provincial digital seismic networks, are a complete list of all the earthquakes in the deployment regions. Of all the waveforms we have processed, many could neither be associated with any earthquakes in the catalog nor be associated with any other events in the global PDE catalog. Figure 5 and 6 show two examples of such waveforms. These events are most likely the local and regional industrial explosions that need to be studied further.

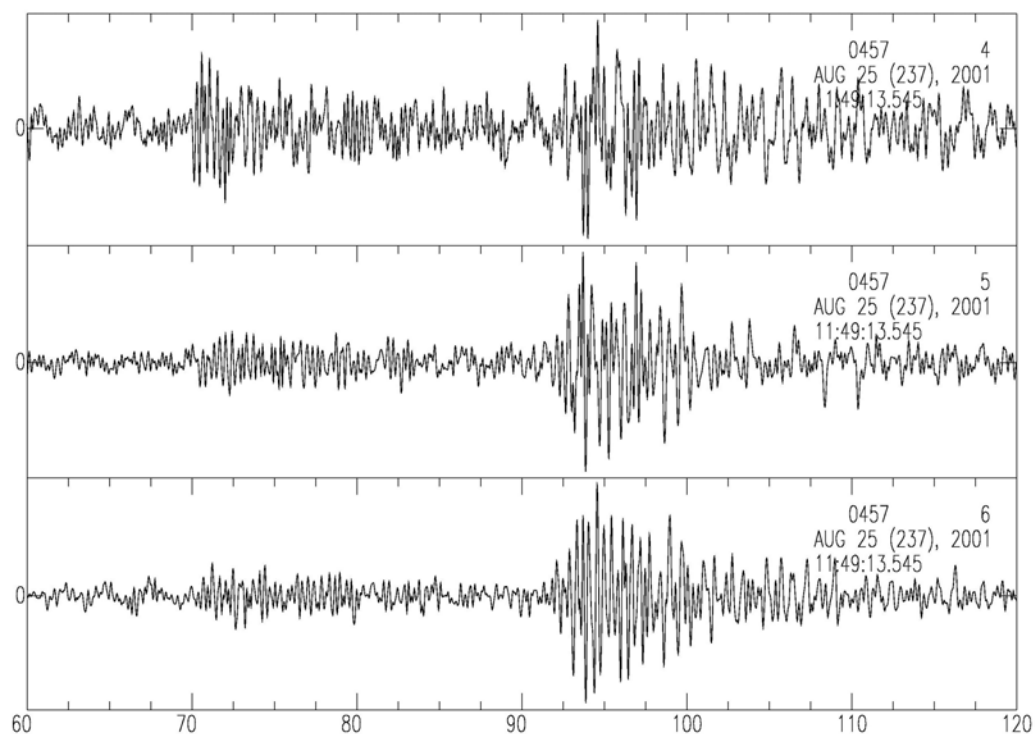


Figure 5. An example of waveforms of a potential industrial explosion recorded at station Zhenyuan, Yunnan province.

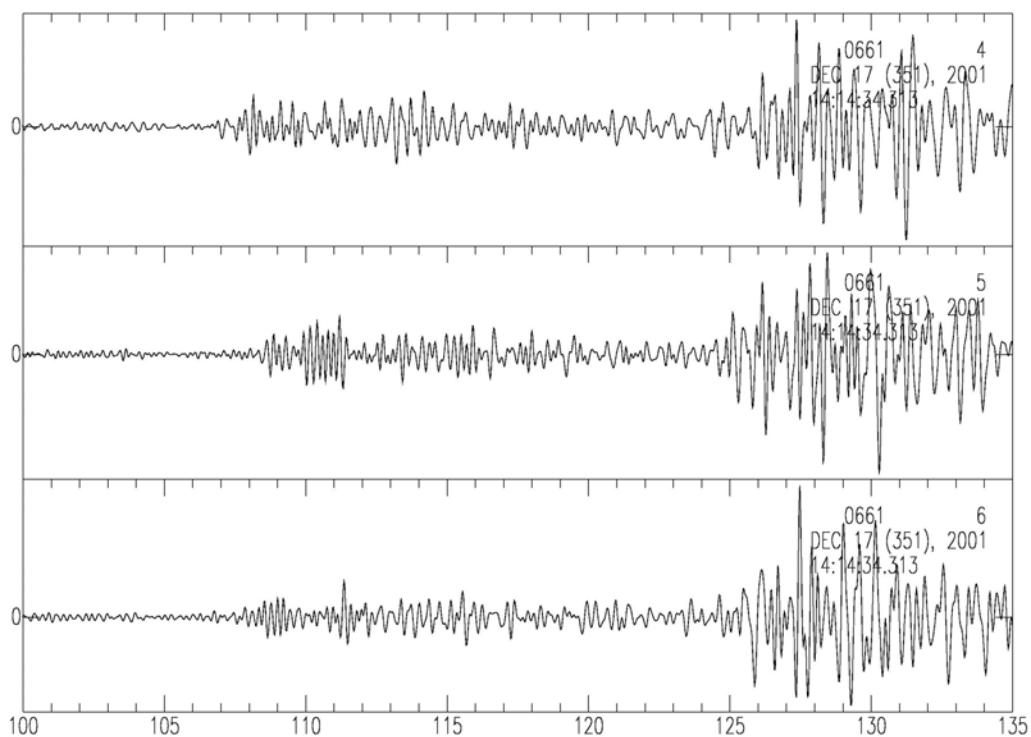


Figure 6. An example of waveforms of a potential industrial explosion recorded at station Mengla, Yunnan network.

Moderate to Large Earthquakes at Teleseismic Distances

The world's moderate to large earthquakes are routinely recorded, including the Nov. 14, 2001, Ms=8.0 Qinghai, China, earthquake, December 18, 2001, Ms=7.3 Taiwan earthquake, September 11, 2001, Ms=6.4 Iran earthquake, October 12, 2001, Ms=7.3 Mariana earthquake, January 2, 2002, Ms=7.6 Vanuatu Islands earthquake, and March 3, 2002, Ms=7.2 Hindu-Kush earthquake, etc. The waveforms from these records are valuable for studying the wave propagation along the paths from Southwest China to many interesting regions in the world, as well as for studying the source mechanism of large earthquakes. Figure 7 shows the waveforms of the October 12, 2001, Ms=7.3 Mariana earthquake recorded at the network.

The June 28, 2002 $M_w=7.3$ Deep Earthquake in Northeast China

On June 28, 2002, a rare, large, deep earthquake occurred in northeast China. The hypocenter was at 130.45E, 43.74N, depth=581.5 km. Our local network recorded this event, with the epicentral distances ranging from 1.7° to 6.5°. Figures 8 and 9 show the velocity and displacement waveforms of this event. Some interesting properties from these waveforms are shown, such as the sharp contrast of the frequency components of P and S waves, as well as a possible "slab phase." Such recordings are extremely valuable for studies on the regional structure, tectonics, and the mechanism of deep earthquakes.

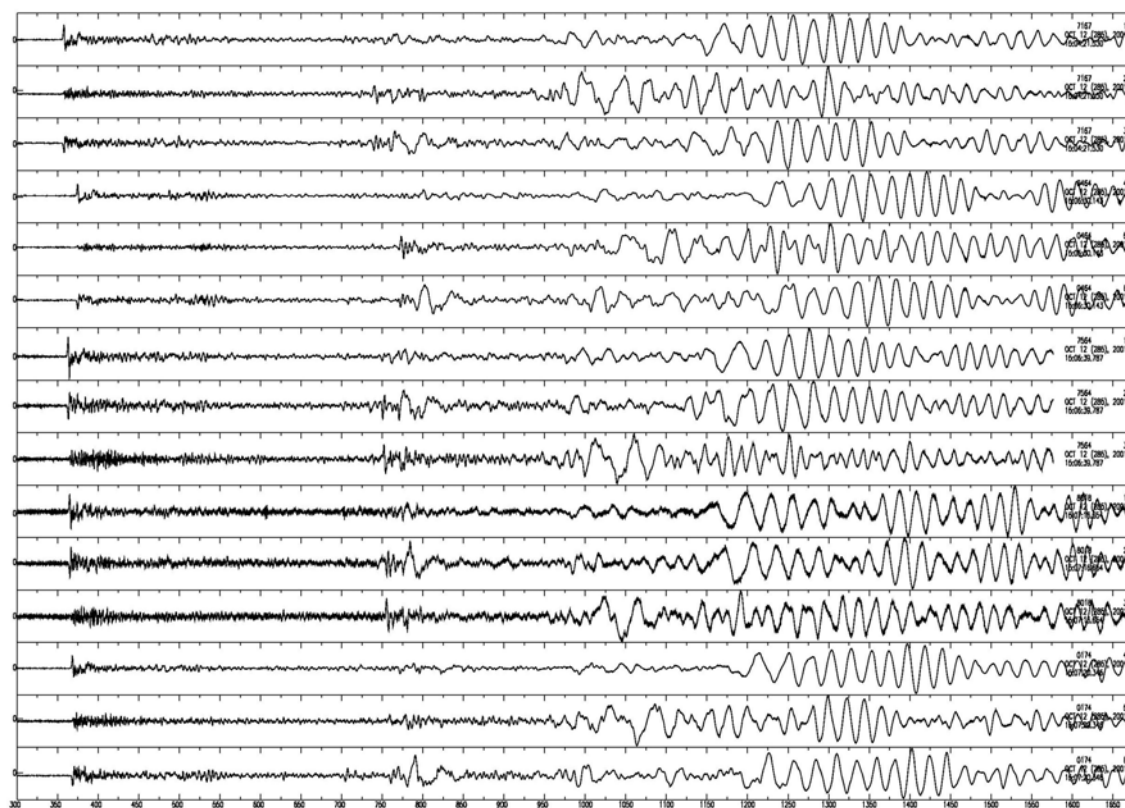


Figure 7. The waveforms of the October 12, 2001 Mariana earthquake recorded at the Yunnan network.

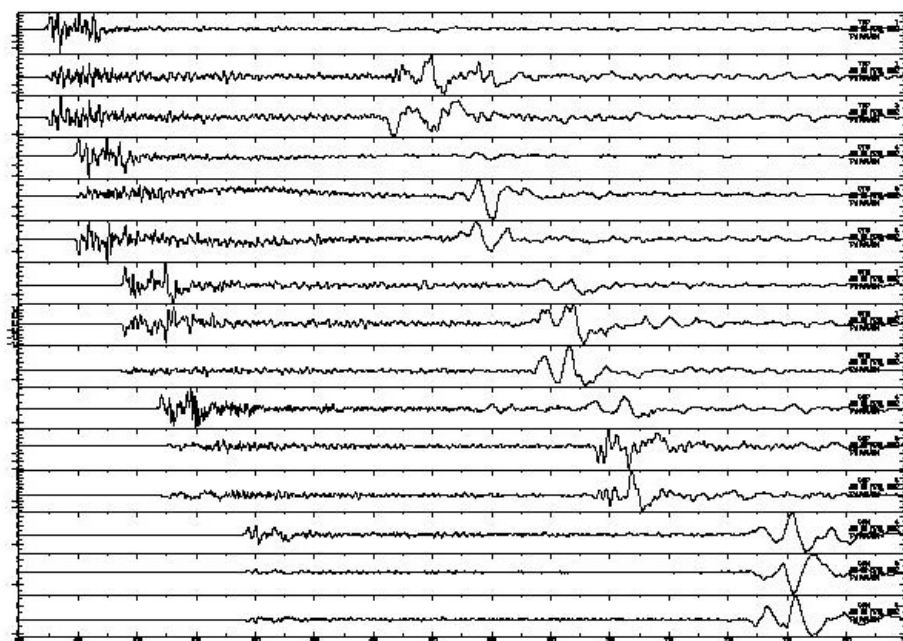


Figure 8. The velocity waveforms of the June 28, 2002, $M_W=7.3$ deep earthquake recorded at the northeast China network.

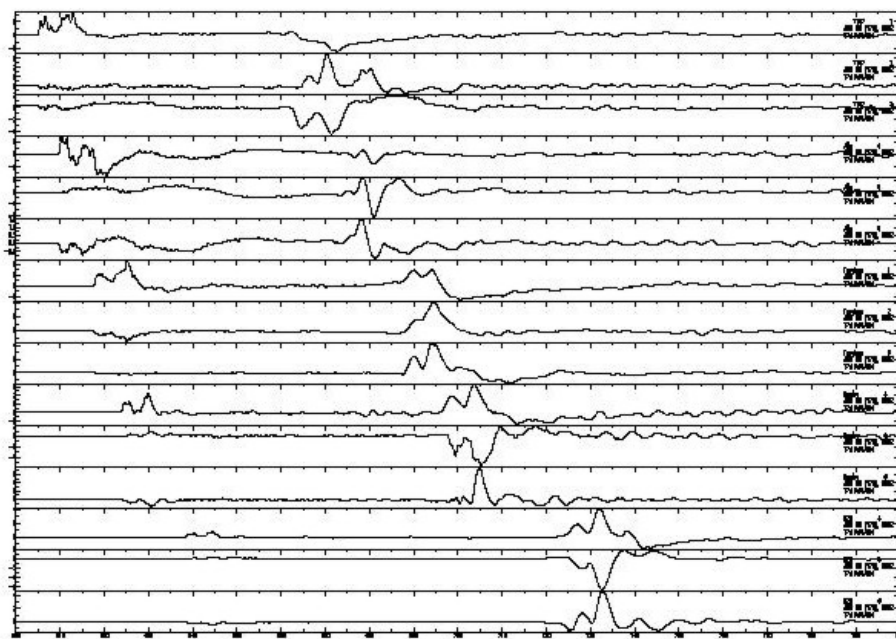


Figure 9. The displacement waveforms of the June 28, 2002, $M_W=7.3$ deep earthquake recorded at the northeast China network.

CONCLUSIONS AND RECOMMENDATIONS

The two broadband seismic experiments conducted in southwest and northeast China are very successful. A high-quality, unique database of waveforms recorded in the experiments is being established. In the database, there are basically waveforms of three kinds of events: the small to moderate local-regional earthquakes, the industrial explosions, and the moderate to large earthquakes at teleseismic distances. A screening of the waveforms shows that more than 15% of events are potential industrial explosions. This database includes tremendous ground-truth information and provides excellent opportunities for studying regional wave propagation, seismic source discriminants, and active tectonics in the experiment areas.

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